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ANNUAL REPORT

MAGNETIC MAPPING OF CURRENT DISTRIBUTIONS IN TWO-DIMENSIONAL ELECTRONIC DEVICES

AFOSR-87-0337

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September, 1988

Publications

"Using a Magnetometer to Image a Two-dimensional Current Distribution," B.J. Roth, N.G. Sepulveda, and J.P. Wikswo, Jr., J. Appl. Phys., in press.

Abstracts of Papers Presented

"High-Resolution SQUID Magnetometers for Biophysics and Non-Destructive Testing," J.P. Wikswo, Jr. and B.J. Roth, Bull. Am. Phys. Soc., 32: 2131 (1987) (Abstract).

"SQUID Magnetometry for Non-Destructive Testing," J.P. Wikswo, Jr., J. Tenn. Acad. Sci, in press (Abstract).

Presentations

"High-Resolution SQUID Magnetometers for NDE: Sensitivity, Spatial Resolution, and Data Analysis," Office of Naval Research SQUID/Non-Destructive Evaluation Workshop, Harper's Ferry, April, 1988.

"Applications of SQUIDS to Biomagnetism and Non-Destructive Testing," Hypres, Inc., Elmsford, NY, June, 1988.

"High Resolution SQUID Magnetometry for Current Imaging: Applications to Biophysics and Non-Destructive Testing," Thomas J. Watson Research Ctr, IBM, Yorktown Heights, June, 1988.

Manuscripts in Preparation

"The Spatial Resolution of One-Dimensional FFT Models for Localizing Current Dipoles," B.J. Roth, S. Tan, and J.P. Wikswo, Jr.

"Current Injection into Two-Dimensional Anisotropic Bidomains," N.G. Sepulveda, B.J. Roth, and J.P. Wikswo, Jr. (Submitted for publication)

"Optimized Designs for SQUID Magnetometer Pickup Coils," B.J. Roth and J.P. Wikswo, Jr.

"The Partial Independence of the Electric and Magnetic Fields of Current Sources in Conducting Media," K.R. Swinney and J.P. Wikswo, Jr.

Patent Disclosures

"Optimized Designs for SQUID Magnetometer Pickup Coils," B.J. Roth and J.P. Wikswo, Jr.

Work in Progress

We have hired Dr. Yu Pei Ma from Boston University/Bitter Lab to work as a research associate on the project, and Mr. Carlos Trenary as half-time staff-member to work on this project. Licheng Li has been hired as a part-time draftsman/mechanical engineer.

The 4-channel, high-resolution SQUID magnetometer system has been ordered from Biomagnetic Technologies, Inc. This system will have a spatial

resolution of approximately 1 mm, and should be received in December, 1988.

The motors for the three-axis, non-magnetic positioning system have been obtained from Burleigh Instruments, after lengthy discussions with Burleigh to eliminate magnetic components from their motors. We are presently incorporating these motors into a sample positioning system.

We are proceeding to assemble the equipment required for the prototype sub-millimeter SQUID system. We have obtained the temperature controller for the existing Janis continuous flow cryostat, and a Cooke 3-inch vacuum system.

We have obtained all of the analog and digital hardware and are presently completing the software for the microcomputer controls of the temperature controller, the pumping system, and the data acquisition system.

We have developed the analytic models required to interpret two-dimensional magnetic field maps in terms of the current distributions that produce them.

We have completed the detailed mechanical design for a 6-foot by 5-foot by 3-foot, four-layer, magnetically shielded enclosure. There will be two layers of one-half inch thick aluminum, each lined with a 0.062-inch thick layer of mumetal. The total shielding factor is expected to be 10^7 at 60 Hz and 10^6 at dc. We are just now sending the drawings out for bid and expect that the shield will be completed before the magnetometer arrives. Over half of the funds for the shield have been obtained from grants from Vanderbilt University

Work Planned for the next 12 months

We will complete the continuous-flow cryostat and its associated magnetometer to allow us to begin several experiments:

Assessing the sensitivity of the SQUID for detecting microcracks.
Mapping current distributions in conductor configurations typical of simple electronic microcircuits.
Mapping current pathways in conducting aggregates near the percolation threshold.
Examination of effects of stress on the magnetic properties of ferromagnetic materials.
Mapping trapped flux distributions in high temperature superconductors.

We will then proceed to refine our instruments and models and then study more complicated problems in non-destructive evaluation. We expect to have a conceptual design for a second-generation SQUID NDE instrument within 12 months.

Anticipated Problems

None

Revisions to Research Plan

None, other than to consider extending our studies to include mapping of current distributions in percolating systems such as granular superconductors.